

No new centre of infection has been discovered up to the present time, and this year a large area of vines surrounding the original phylloxerised centres has received treatments of cultivation varying from 24 to 60 grammes of Bisulphide per square metre.

These treatments have been given a little late in the year, in order to allow the development of the *winter-egg*—which I have not met with here, but before the exodus of the winged form has begun.<sup>(4)</sup>

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## ON THE ORIGIN OF THE DIAMOND-MINES OF SOUTH- AFRICA.—By R. MARLOTH, Ph.D.

[Read 1886, March 31.]

More than fifteen years have elapsed since digging for diamonds was started on the places still bearing the name of Diamond Fields, although they are surrounded now by well populated cities. This corner of Griqualand West has become of the highest importance for the whole of South Africa, but the more scientific question about the origin of these wealth-producing mines has not been sufficiently answered as yet. I do not pretend to give a new theory which disposes of all the difficulties and all the doubts respecting the formation of the mines, but I hope that the following remarks may contribute a little towards the solution of this problem, so that future geologists, aided by a larger amount of observation, may succeed, where we with our fragmentary knowledge thereof still fail.

All those who take some interest in the question know that the diamondiferous mineral, the blue ground of the digger, is found only in funnel-shaped holes, the bottom of which has not been reached yet. There are four such holes principally worked at present, but as Kimberley Mine, where sinkings have been made down for a depth of 600 feet, is the best explored of all, I restrict myself to this mine.

The general opinion as to its formation is, that the orifice has been formed by volcanic forces, and that the blue has been upheaved from a greater depth, transporting thus the diamonds to their present place. However, this orifice is not the crater of a volcano, as has been stated in various publications, for instance by Mr. Chaper in his book "Note sur la région diamantifère de l'Afrique australe." It is only the pipe which connected the crater with the interior of the globe, and the crater, if there was any at all, has been washed away during the long denudation which altered entirely the surface of South Africa.

So far the question is pretty clear; but a more serious divergence of opinions exists on the state in which the diamondiferous mineral came to its present place. Some geologists, as for instance Mr. Dunn, who is now in Australia, and Professor Cohen from Strassburg, declare it to be an igneous product, a kind of lava, which filled out this volcanic orifice and hardened there. They mention in favour of their theory especially the nature of the mineral, which they class near to the serpentine. But how, I must ask at once, is it then to be explained, that not a single bit of the numerous fragments of the various rocks and shales, embedded in the blue, exhibits a sign of fusion or alteration by heat? This ought to be certainly the case, if the blue stuff,

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<sup>(4)</sup> The exodus of winged females began on the 13th of January, 1887, and this year on the 1st of the same month.

which surrounds these fragments now, was in a fused state. Whether lava or trap at such a high temperature has filled out cracks or holes in other rocks we find the adjoining rock altered, mostly fused by the enormous heat acting on it. But the minerals of Kimberley Mine show nothing of this kind. And then, how is it to be explained that some fossil remains, as coal-bearing shales and shells have been found imbedded in the blue? To prevent any misapprehension, I beg to state, that I do not mean to say that these fossils had been originally deposited in the blue. They came most probably out of the surrounding shales or from the surrounding country, but they have been mixed with the blue stuff when it was fluid or soft, and they are well preserved, as I have myself seen. Neither the wood nor the shells would have resisted such a high temperature as the melted mass possessed.

These important objections have led to another theory, which considers the mineral to be an aqueous product, it having been upheaved in a muddy state. As this mud-volcano theory appears to be the prevailing opinion among mining men, I think it necessary to examine a little closer the principal points of it, which have been put forth by Mr. Chaper as follows:—

1. The mineral, now called the "blue," has been ejected as an aqueous mud.
2. This mud possessed a low temperature.
3. It was very thin and fluid, having mixed up with it all the garnets, pebbles, fragments of rocks, &c.
4. The stuff which fills out now the interstices between these pebbles is a kind of serpentine, which was dissolved in the water.
5. The whole mass was not ejected at a single eruption, but at several intervals and in thin layers.
6. The hillock which formerly covered the spot, where now Kimberley Mine is, was the cone of ejection of this mud-volcano.

Points number one and two are supported by the occurrence of unaltered fossils and fragments of rocks without any sign of fusion.

The contention under 3, that the mud has been of a very great fluidity, is proved by the fact of its having entered into very thin crevices of some fragments of slate, found imbedded in it and originating evidently from the rocks which form the walls of the mine.

To the fourth point I must object, as the serpentinic matter could not have been *dissolved* in water. It was simply mixed with it, forming a thin mud.

For the support of the fifth point, Mr. Chaper mentions certain lines in the blue, which apparently separate different layers, but I do not think that this conclusion is sufficiently proved.

The assertion under number six I cannot admit at all. But before showing that the formation of the hillock has taken place in a very different way, I may mention another fact, which has remained unexplained to the present day, namely the occurrence of small pebbles, larger stones and huge boulders in the blue, the surfaces of which are smooth, as if they had been for a long time in moving water before they came to their present place. These pebbles are a puzzle to Mr. Chaper as well as to other geologists. I find nowhere an attempt to account for their presence in the mineral. I may therefore be allowed to venture the following hypothesis thereon.

We know that the diamond fields were once covered with water like the greater part or the whole of South Africa. There is nothing to show that this inundation had come to an end when the volcanic eruption took place which formed these orifices. On the contrary, a great deal of denudation has gone on since that catastrophe happened. I think it, therefore, very probable that the eruption took place during the submersion of the country, and that all these water-worn pebbles and boulders were washed in by the water, either immediately after the first eruption or during the time that the fused mass in the orifice was kept boiling. At last the water overpowered the fire and the mass hardened. The immense hydraulic pressure from the overlying water would account at the same time for the highly hydrated state of the diamondiferous mineral, which is therefore neither an igneous nor an aqueous formation, but a child of both fire and water.

In the light of this theory all the objections I had to raise before, vanish, and I may therefore proceed to deal with the last of the six points mentioned by Mr. Chaper.

He and a good many other persons were struck by the fact that, as far as each of the four mines extended, a flat hillock rose above the surrounding plain. These hillocks were therefore supposed to be the cones of ejection of the mud-volcanos. I think, however, that the formation of the hillocks is much more recent than the origin of the mines themselves. I take, again, Kimberley Mine as an example, and I may mention for the sake of those who are not sufficiently acquainted with the geological points I have to refer to that a section through the hillock of Kimberley Mine—the Colesberg Kopje—would have shown the following strata:—

At first a thin layer of red sand, about one foot thick, then a limestone conglomerate, several feet thick, both these layers extending equally over the mine and the surrounding country. Within the orifice came then the diamondiferous ground, which was yellow to a depth of 20 to 30 feet, then becoming blue and much harder.

The yellow ground is evidently nothing but a decomposed blue, which has changed its colour by the decomposition. Now we know that the blue ground in decomposing increases its volume, and a mining engineer states, that 60 loads of blue give 100 loads of decomposed ground. The proportion is therefore 3 to 5. Let us, then, see what the increased volume of this decomposed blue in Kimberley mine would be. Putting down the surface of the blue equal to  $n$  square feet, the original height of the decomposing layer at its average to 25 feet, we find its original volume to be  $n \times 25$  cubic feet, and its increase after decomposition equal to  $n \times 25 \times \frac{2}{3}$  cubic feet. If this process of increase took place in the open air the mass would have formed a cylinder on the top of the mine. But we know that the mine was covered by a solid layer of lime-conglomerate, and although this crust of lime has been formed in a comparatively recent period, it complicates the question a little. The extending forces in the decomposing mass could neither succeed towards the bottom nor towards the sides, and on the top they were resisted by this limestone crust. The pressure in the mass must have accumulated, therefore, to a certain extent, and it did so the most in the centre of it. The highest intensity of pressure prevailing in the centre, it is evident that the overlying crust will have been lifted at first on this spot. Once an

outlet given, the whole mass striving for extension, and being only of a very low elasticity, has balanced this pressure by forming a flattened cone.

For better demonstration of this phenomenon, I may mention an experiment, which is well known to all of us, at least to our lady visitors, although I do not think that the fair experimenters ever became aware of the bearing of their observation. The experiment I speak of, is the baking of a cake in a mould. The bottom and walls of the mould correspond to the underlying blue and the surrounding rocks of the mine, and the crust which is formed at the beginning of the baking process is analagous to the limestone layer which covered once the mine. In both cases there remains inside a mass, elastic to a certain degree, striving for extension and—just as the crust of the cake is almost always lifted at first in the centre, very often cracking thence in several directions—so the decomposing ground of the Kimberley mine formed the little hillock, the late Colesberg kopje.

It might be of some interest to estimate the height of this hillock. The increase of volume was found to be  $n \times 25 \times \frac{2}{3}$  cubic feet. This forms a cone, the base of which is  $n$  square feet, its height  $x$  feet. As the formula for the contents of a cone is  $c = \frac{b \times h}{3}$ , we come to the following equation:  $n \times 25 \times \frac{2}{3} = n \times \frac{x}{3}$  that is,  $x = 50$ . That means to say, the top of the formed cone would have been 50 feet above the surrounding country, if all had happened in a mathematically correct way. The actual height of the hillock was, however, only twelve or fifteen feet, which is not at all surprising, as the conditions under which the formation took place are very different from those to which the blue ground is exposed on the depositing floors, so that the increase of volume will have taken place only in a smaller degree.

I hope to have succeeded in showing that the little hillock on the top of the mine is not necessarily of volcanic origin, that it is not a cone of ejection, but that it is the result of the forces which were dormant in the blue, and have been set free only to a small extent during the hundred thousands of years elapsed since the time when Griguland West and the surrounding countries were yet covered by the waters.

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